Strain Effects on Charge and Orbital Order in $Pr_{1-x}Ca_xMnO_3$ Films

Beamline: X22C and 9ID (CMC-CAT, APS)

Technique: X-ray Scattering

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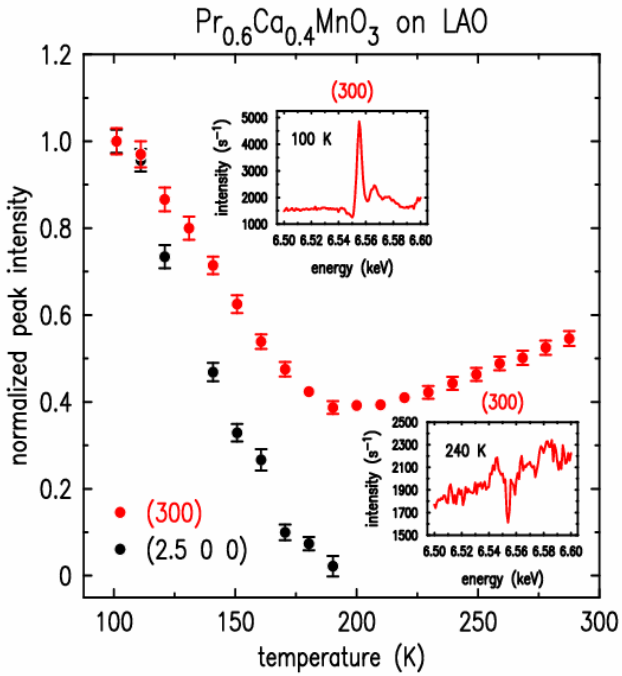
Motivation: Manganite films have been of interest since the first observation of the colossal magnetoresistance effect in a perovskite-type film (Jin *et al*., Science **264**, 413 (1994)). The change in resistivity, which in the $Pr_{1-x}Ca_xMnO_3$ system is accompanied by a melting of the charge and orbital order, immediately suggested device applications based on the sensitivity to magnetic fields. For all manganite film applications, a key parameter in the behavior of the system is the strain caused by a lattice mismatch between the manganite material and the substrate. In order to study the effects of this strain in $Pr_{1-x}Ca_xMnO_3$ films, we have used x-ray scattering techniques to probe films grown on substrates that provide different types of strain.



Fitted values for the (300) charge (•) and (2.5 0 0) orbital (•) order peak intensities, normalized to equal 1 at a temperature of 100 K. Insets show energy scans carried out at the (300) peak at temperatures of 100 and 240 K.

Results: In films with x = 0.3 and 0.4 dopings, different crystallographic symmetries from the bulk materials were observed. In addition, charge and orbital order were found to be more robust under compressive— as opposed to tensile— strain. In fact, only in the films grown on lanthanum aluminate (LAO) were bulk-like charge and/or orbital order observed. Evidence of this ordering in the x = 0.4 film can be seen in the figure, which displays fitted peak intensities at both charge and orbital order wavevectors. In this film, the ordering temperature, as determined by the vanishing intensity at the orbital order wavevector, is reduced compared to that observed in the bulk material (~245 K). While the peak at the charge order wavevector persists above this temperature, the energy scans (see insets) indicate that the charge order, which exhibits a resonant enhancement only at low temperatures, has disappeared and only a weak Bragg peak— no longer forbidden, as in the bulk material, because of the different crystallographic symmetry— remains. These studies underline the significant effects of strain in the behavior of manganite films.